DEVELOPMENT OF AGRICULTURAL AND INDUSTRIAL WASTE BASED NOVEL FORMULATION FOR SUSTAINABLE AGRICULTURE

A SYNPOSIS OF RESEARCH WORK PROPOSED TO BE CARRIED OUT IN PURSUANCE OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF

DOCTOR OF PHILOSOPHY

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INTRODUCTION

The current situation throughout the world strongly emphasizes the need for adopting environment friendly agricultural practices. There is growing perception among scientific communities, academicians and policy makers that sustainable use of agricultural, industrial wastes and soil fertility should be accorded high priority in conservation, enhancement of land productivity and environmental protection programmes (Raut et al., 2011). Land resources on a global perspective are under immense pressure and this pressure is continuously increasing due of growing world population, land degradation, global economic development, and urbanization etc (Prasad, 2015). Agricultural sustainability is the basic requirement to combat land degradation and to feed ever-increasing human population. It can only be maintained by application of sufficient quantity of organic matter in the agricultural soil. Due to scarcity of dung manure and over production of agricultural and industrial wastes, it is the demand of time to integrate the use of these resources for sustainable agricultural soil management.

Disposal of agricultural wastes is one of the major environmental concerns throughout the world today (Dhammapala et al., 2006). Agricultural wastes are directly disposed of either as solid waste or burned in open. Burning of stubble of crops like paddy and wheat has adverse impact on the environment and become a source of pollution throughout the world (Chan et al., 2006; Mahli et al., 2007; Mittal et al., 2009). According to the Indian Ministry of New and Renewable Energy (MNRE), India generates on an average 500 Million tonnes of crop residue per year. The same report shows that a major amount of crop residue is used as fodder, fuel for other domestic and industrial purposes. Remaining amount 140 MT (million tonne) out of which 92 MT is burned each year. It is an interesting fact that the portion of waste burnt in India is much larger than the entire production of agricultural waste in some countries (NPMCR, 6 March 2019). Biological processes such as composting/vermicomposting to convert them into useful organic manure would be of great benefits for sustainable agricultural soil management (Fauziah et al., 2009; Sangwan et al., 2010). Composting/vermicomposting can be integrated with other industrial wastes and microorganisms to enhance its quality and nutritional value (Abdelhamid et al., 2004; Yang et al., 2013).

Industrial waste dumps also occupy large land area and causes significant ill impacts on environment. For every 100 tonnes of sugarcane, crushed approximately three tonnes of press mud cake left behind as byproduct. Presently about 704 sugar mills are running in the country with annual byproduct production about 8 million tons in the form of press mud (Gupta et al., 2011; Kumar et al., 2017). Recently, various researchers have shown that industrial wastes like press mud either alone or in combination with other inputs may be used as valuable soil amendments as they are capable of improving physico-chemical properties of soil on the one hand and supply essential major and micro nutrient to the crop on the other hand (Seth et al., 2005; Sarwar et al., 2010; Bhat et al., 2016). Results of industrial wastes application in sodic soil revealed that combination of press mud along with fly ash can be successfully used for cultivation of medicinal and aromatic plants in such types of soil (Anonymous, 2015).

Generally biodegradable waste is integrated with partially decomposed dung for converting them into organic fertilizer but due to limited availability of dung in urban areas like urban vegetable farmhouse, universities, research institutions, other government and non government enterprises these waste are not converted into organic manure. These wastes are disposed off either by dumping them in open areas are burned in open areas. Both the methods are hazardous and cause environmental pollution. So, it is demand of time to explore alternatives of dung for composting process. In this regard press mud may be used as an alternative of dung because it contains sufficient organic matter to initiate composting/vermicomposting process. Keeping above view in mind present study is proposed with the ultimate goal for the development of a formulation to be used as manure and soil conditioner.

Proposed study offers cost-effective and eco-friendly approach for the management of sustainable soil, industrial and agricultural waste management. It serves the purpose of agricultural sustainability and provides an opportunity to use these resources for ecological services and income generation. Some advantageous aspects of proposed study are as under-

- Minimum financial outlay to purchase chemical amendments.
- Besides macronutrient, it will also provide micronutrients like Fe, Zn, Cu, Ca, Mg, B and S etc.
- Promotion of soil-aggregate stability and improvement in physico-chemical and biological properties of soil.

- Enhancement in the water holding capacity of the soil.
- Due to increment in the biological activity, the supplements that are in the lower depths are made accessible to the plants.
- It acts as much consequently minimize the evaporation losses of moisture from the soil.
- Ecological considerations as far as carbon sequestration in the post enhanced soil.
- Contribute to **"Swachh Bharat Abhiyan"**.

OBJECTIVES

1. Development of novel formulation from agricultural and industrial wastes.
2. Characterization of the physico-chemical and nutritional properties of the developed formulation.
3. To study the effect of developed formulation on overall soil health (physico-chemical, biological and safety) parameters.
4. To study the effect of developed formulation on plant growth, biochemistry, yield, quality and safety parameters for aromatic crops (*Cymbopogon flexuosus* and *Chrysopogon zizanioides*).

REVIEW OF LITERATURE

The accumulation of waste has expanded along with the rapid rise in agricultural land, residential societies, fast food outlets, vegetable markets, fruit shops and other client outlets in separate zones. As indicated by Edwards and Batar (1992), the sum of solid reject is continually expanding and its treatment and removal has gotten a significant social and environmental issue just as a challenge. The removal of these materials causes broad undesirable smell issues and contamination of ground water. Hence, reinforcing our current environment through proper treatment of waste is a principal need of the hour (Manimozhi et al., 2006). It is fundamental to distinguish an appropriate methodological substitute to reduce the environmental problems related with the management of waste (Velázquez-Cedeño et al., 2002). Composting and vermicomposting are the sustainable solution for the management of natural wastes. As a procedure for managing natural matter, it serves as a reasonable method for the management of waste, wherein the material is neither land neither filled nor burned, or maybe it is treated as a resource that may be reused.

Farmyard manure (FYM) is the most popular and important form of organic manure. It was the only recognized source of plant nutrients added to the soil before the introduction of chemical

fertilizers in the middle 19th century. FMY is rich in microbial populations and diversity, particularly fungi, bacteria and actinomycetes. FYM is considered as a good source of organic matter and plant nutrients and when incorporated into the soil, it improves physical and chemical properties of soil (Prasad, 1994). Gomez et al. (1996), the continuous and imbalanced use of inorganic fertilizers cause's macro and micronutrient deficiencies, decline in organic carbon in the soil, causes health and environmental hazards and deterioration in the soil fertility. Yilmaz and Alagoz, (2010), FYM affects physical, chemical and biological properties of soil like, microbial population including maximum water holding capacity. Garg, (2008), the management of agricultural waste using living organisms (microbes & earthworms) could also be an excellent option for the detoxification of the soil and mitigation of environmental pollution.

Role of worms in the breakdown of natural waste on soil surface and soil turn over process was first featured by Darwin (1881). It has required right around a century to see the value in their significant contribution in controlling natural pollution and giving topsoil to impoverished lands. Vermicompost contains most of the nutrients such as nitrates, phosphates and exchangeable calcium and soluble potassium in plant available form (Orozco et al., 1996; Edwards 1998). Vermicomposting with *Eisenia foetida* of mustard residues and sugarcane trash mixed with cattle dung in a 90 day composting experiment showed the significant reduction in C: N ratio & increase in mineral N (Singh and Sharma, 2002). Vermicompost consistently promotes biological activity which can cause plants to germinate, flower, grow and yield better than in commercial container media, independent of nutrient availability (Atiyeh et al., 2000 a, b; Arancon et al., 2004). Thakur, (2006),vermicomposting requires a specific species of worms that is adapted to living in decomposing organic materials rather than the soil. Two such species are *Eisenia foetida*, all the more regularly known as the red worm, compost worm or red wiggler and *Lumbricusrubellus*. Most vermicomposts contain adequate amounts of macronutrients and trace elements of various types; anyway these depend upon the substrate available to the earthworms (Werner and Cuevas, 1996). Seenappa and Kale (1993) have each advocated vermicomposting and the management on parts of sugar factory waste, solid wastes from the aromatic oil industries, and distillery waste in India. Frederickson et al. (1997) and Karthikeyan et al. (2007) performed the stabilization of green waste, for example, yard waste and vegetable waste through the

procedure of composting and vermicomposting.

Atiyeh *et al.* (2000) recorded that the traditional compost has a more amount of 'ammonium', while it was determined that the vermicompost has a higher amount of 'nitrates', which is the readily available form of nitrogen to help prevalent growth and yield. They also found that vermicompost has higher N accessibility and other plant supplements like Phosphorus (P), Potassium (K), Sulfur (S) and Magnesium (Mg), demonstrated impressive increment when vermicompost was added to the soil as as compared to traditional compost. Shanti et al. (2012) investigated the relative percent content of nitrogen and phosphorus in partially decomposed and vermicompost samples. It was observed that nitrogen and phosphorus content was seen as higher in the partial decompose (3% and 0.4% respectively) and lower in vermicompost (0.2% nitrogen and 0.28% phosphorus). The study also helped in isolating efficient nitrogen fixing and phosphate solubilizing microorganisms which could be evaluated further for their viability towards growth and yield of crop.

The supplement status of the distinctive agro-industrial waste, for example, press mud, bagasse, coir waste, rice husk and ground shell was also evaluated and it was found that vermicompost samples ready from agro-industrial waste recorded genuinely more significant level of supplements (Sushma et al., 2007). Diaz, (2016) reported that press mud which is utilized to provide a nutrient rich, high quality organic matter when it apply to the soil as manure results in better sustainable yield. Arumugam et al., (2017) describe that in the study two different approaches towards the management of paper cup waste through vermicomposting technology. The experimental setup includes 2 plastic reactors namely Vermicompost (VC) (Cow dung + Paper cup waste + Earthworm (*Eudrillus eugeinea*) and vermicompost with bacterial consortium (VCB). Usmani et al., (2019) reported that they converted coal fly ash waste into valuable manure by composting and vermicomposting (VC) techniques over a duration of 60 days. So, altering the physico-chemical, microbial population, level of plant hormones, microbial biomass was higher in the vermicompost as compared to the compost. Vermicomposted fly ash amendments significantly improved the soil quality. Yuvaraj et al., (2020) the examination reveals that dairy cattle waste is indispensable material for vermicomposting innovation to ensure agricultural and environmental sustainability by decreasing contamination hazards related with biowastes on one hand, and supplement rich amiable vermifertilizer production on the other hand.

MATERIALS AND METHODOLOGY

- **Materials**

a) **Agricultural Waste:** Agricultural waste refers to waste produced from agricultural operations, including waste from farms and poultry houses like crop residues, weeds, leaf litter, sawdust, forest waste, paddy stubble. In addition to being potentially damaging to the environment, agricultural waste may expose workers to harmful biological material (biohazards). Storing agricultural waste can multiply the hazards associated with it since stored waste can release harmful gases. It will be collected from field sites of Dayalbagh.

b) **Press mud:** Press mud is the waste by-product from sugar mills. It is the compressed sugar industry waste produced from the filtration of the cane juice. The press mud is very useful for agricultural and horticultural crops due to richness in various micronutrients (Nitrogen 1.9%, Phosphorous 1.8%, Potassium 0.9%, Calcium 4.3%, Magnesium 0.7%, Sulfur 3.2%, Sodium 0.1%, Manganese 0.034%, Zinc 0.008%, Copper 0.053%) (Gupta et al., 2011). It will be collected from a local Sugar Mill, Uttar Pradesh (India).

c) **Decomposer:** Waste decomposer is very essential for early pre-decomposition of organic waste.National Centre of Organic Farming (NCOF) has developed a waste decomposer culture (consortium of microorganism) which is used for quick composting from organic waste, soil health improvement and as plant protection agent. It will be procured from National Center of Organic Farming (NCOF) Govt. of India.

d) **Earthworms:** An *earthworm* is a small, legless, tube-shaped animal that lives in soil, which is common in healthy garden dirt. Species of earthworms are *Eisenia foetida* (red earthworm), *Eudrilus eugeniae* (night crawler), *Perionyx excavates* etc. *Eisenia foetida* will be utilized because of its high multiplication rate and have great temperature resistance so they can live in organic wastes with different moisture content. The temperature capacity to bear *Eisenia foetida* is between 0^{o}C to 35^{o}C, and ideal temperature is 25^{o}C. It can survive in moisture ranges between 50-90% (Sims and Gerard, 1985). However, it can also grow more quickly in between 80-90% moisture ranges (Edwards, 1988). It is a surface feeder it converts organic matter into vermicompost from top. It will be procured from IABF Organic Fertilizer, Village Runakta, Agra.

➢ METHODOLOGY

I. EXPERIMENT 1

DEVELOPMENT OF NOVEL FORMULATION

First of all suitable agricultural waste like paddy stubble will be collected from Dayalbagh. It will be segregated, shredded, air dried then pre-composted with the help of waste decomposer developed by NCOF (National Centre of Organic Farming) / other reputed institutes. The experimental treatments will be conducted on the pit/kaccha floor by making beds of same size. The bed will be filled with pre-composted agricultural waste/press mud/dung as per the treatment. Next day Earthworms (*Eisenia foetida*) will be inoculated in the bed. The vermi-bed will cover on the top by a jute material and also thin polythene to protect the earthworms from the predators; centipedes and shrews and to prevent the moisture loss. Little gaps will penetrate at the base of polythene for air flow and easy drainage. The vermi-bed will be incubated for 90 days. Temperature will be maintained for 28^{o}C-32^{o}C and sufficient moisture will be maintained by sprinkling water as per need. After completion of vermicomposting process developed formulation will be analyzed for physico-chemical and nutritional properties to identify best formulation.

Treatments details:

- **T1** 100%Press mud
- **T2** 100%Cattle Dung
- **T3** 70% Pre-composted agricultural waste + 30% Press mud
- **T4** 50% Pre-composted agricultural waste + 50% Press mud
- **T5** 70% Pre-composted agricultural waste + 30% Cattle Dung
- **T6** 50% Pre-composted agricultural waste + 50% Cattle Dung
- **T7** 70% Pre-composted agricultural waste + 20% Press mud + 10% Cattle Dung

CHARACTERIZATION OF NOVEL FORMULATION

a) Analysis of Physico-chemical of developed formulation

- Moisture content (Jackson,1973)
- Temperature (Jackson,1973)
- pH (Jackson,1973) measured by using pH meter

- EC (Jackson,1973) measured by using EC meter
- Bulk density (Blake and Hartge, 1986)
- Particle density (Kretz, 1974–1975)
- Total porosity (Schlichting et al. 1995)

b) Analysis of Nutritional properties of developed formulation

- Organic Carbon (Nelson & Sommers,1996)
- Macro and micronutrients
    - Total Nitrogen [N] (Singh and Pradhan, 1981)
    - Available Phosphorus [P] (Bhargava and Raghupathi, 1993)
    - Exchangeable Potassium [K] (Bhargava and Raghupathi, 1993)
    - Calcium [Ca] (Cheng and Bray,1951)
    - Magnesium [Mg] (Cheng and Bray,1951)
    - Sulphur [S] (Bardsleyand Lancaster,1960)
    - Boron [B] (Aznarez, Bonilla and Vidal, 1983)
    - Iron [Fe] (Loveland and Digby, 1984)
    - Zinc [Zn] (Shaw and Dean, 1952)
    - Copper [Cu] (Lindsay and Norvell, 1978)
- Microbial Biomass Carbon (Jenkinson and Powlson, 1976)

II. EXPERIMENT 2

EFFECT OF DEVELOPED FORMULATION ON OVERALL SOIL HEALTH

The developed formulation will be applied in soil and incubated at room temperature for 90 days. After that overall soil health will be analyzed and compared with initial soil health to access the potential of developed formulation (Prapagaret al., 2012).The best formulation will be evaluated on aromatic crops for plant growth, yield and safety parameters.

Soil health parameters:

- Moisture content (Jackson,1973)
- Temperature (Jackson,1973)
- pH (Jackson,1973) measured by using pH meter

- EC (Jackson,1973) measured by using EC meter
- Bulk density (Blake and Hartge, 1986)
- Particle density (Kretz, 1974–1975)
- Total porosity (Schlichting et al., 1995)
- Organic carbon (Nelson & Sommers,1996)
- Macro and micronutrients
    - Total Nitrogen [N] (Singh and Pradhan, 1981)
    - Available Phosphorus [P] (Bhargava and Raghupathi, 1993)
    - Exchangeable Potassium [K] (Bhargava and Raghupathi, 1993)
    - Calcium [Ca] (Cheng and Bray,1951)
    - Magnesium [Mg] (Cheng and Bray,1951)
    - Sulphur [S] (Bardsleyand Lancaster,1960)
    - Boron [B] (Aznarez, Bonilla and Vidal, 1983)
    - Iron [Fe] (Loveland and Digby, 1984)
    - Zinc [Zn] (Shaw and Dean, 1952)
    - Copper [Cu] (Lindsay and Norvell, 1978)
- Microbial biomass carbon (Jenkinson and Powlson, 1976)

III. EXPERIMENT 3

EFFECT OF DEVELOPED FORMULATION ON PLANT GROWTH, BIOCHEMISTRY, YIELD, QUALITY AND SAFETY PARAMETERS

Experiments will be conducted to study the effects of developed formulations on *Cymbopogon flexuosus* (Lemongrass) and *Chrysopogon zizanioides* (Vetiver). The field experiments will be conducted at Department of Botany, Dayalbagh Educational Institute, Dayalbagh, Agra (Uttar Pradesh). The crops will be established, and data regarding growth (number of tillers, shoot length, biomass production and yield), biochemical (chlorophyll, carotenoids), oil content and oil quality will be collected under field conditions. Physico-chemical properties of soil before crop establishment and after harvesting will be analyzed to evaluate the changes in soil due to application of formulation and crop cultivation. Soil and plant materials will be analyzed for safety parameters.

Treatments details:

- **T1** No fertilizer application
- **T2** Recommended dose of NPK fertilizer
- **T3** Developed formulation @ 15 t/h
- **T4** Developed formulation @ 20 t/h
- **T5** Developed formulation @ 25 t/h
- **T6** Developed formulation @ 15 t/h + Half dose of recommended NPK
- **T7** Developed formulation @ 20 t/h + Half dose of recommended NPK
- **T8** Developed formulation @ 25 t/h + Half dose of recommended NPK
- **T9** Developed formulation @ 15 t/h + PGPR
- **T10** Developed formulation @ 20 t/h + PGPR
- **T11** Developed formulation @ 25 t/h + PGPR

Replication: Four replicates of treatments will be taken for the proposed work.

Design: Complete Randomized Block Design

Crops: Aromatic crops *Cymbopogon flexuosus* (Lemongrass) and *Chrysopogon zizanioides* (Vetiver) with standard agronomic practices.

a) Analysis of biochemical changes in response to various treatments in different plant matrices

- Chlorophyll content by Lichtenthaler method, 1987.
- Carotenoid content by Lichtenthaler method, 1987.

b) Analysis of oil content and oil quality in response to various treatments.

- Essential Oil will be extracted according to Guenther (1955) by hydrodistillation method using Clevenger's apparatus. Oil content will be estimated by following formula-

$$\text{Oil content} = \frac{\text{Weight of Grass}}{\text{Volume of oil}} \times 100$$

- Quality of essential oil is will be analyzed by GC-MS (Reverchon and Senatore, 1994).

c) Analysis of safety parameters in various plant matrices (roots, stem and leaves)

The press mud, developed formulation and plants samples (1 gm each) will be digested with a mixture of nitric, sulphuric and perchloric acid (6:1:2 by volume) at 100°C. Digested material will be diluted with deionized water and heavy metal contents will be detected using Atomic Absorption Spectrophotometer (AAS) [Apha, 1976].

EXPECTED OUTCOMES

- Agro-Industrial waste utilization would eventually benefit agricultural as well as sugar industry.
- The combination of agricultural waste with press mud could be high-value manure.
- Developed formulation will increase the plant growth as well as productivity by providing nutrient supply.
- Developed formulation will be cost-effective and comparatively pollution-free.
- It will help to reduce the volume of agro-industrial waste.
- The proposed study will generate additional revenue and employment.
- Vermicompost technology can be successfully applied for solid waste management strategy using agricultural as well as sugar industry waste.

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